DISCUSSION.

C. F. MARVIN, Chief, U. S. Weather Bureau.

The note by Professor Simpson is most timely and appropriate, with reference to opportunities of employment in meteorological lines of pursuit. The Chief of Bureau is pleased to encourage to the greatest possible degree the attainment of qualifications in meteorology for prospective service in the Weather Bureau. However, it does not seem amiss to say that under the schedules of the reclassification of Govenment employees the range of salaries is from $1,600 to maximums of $5,000 or $6,000, but it is quite obvious that the higher salaries go to a limited number of persons peculiarly qualified and occupied with difficult and specific lines of work. The greater number of employees of the Bureau are expected to perform extremely important duties in the administration of field work of the bureau concerned with forecasting, the conduct of stations in large and small cities, and the performance of a daily program of service to the public. Technical education, together with executive qualifications and keen business sense, are essential to the highest share of success.

It should not be supposed that employment in the Weather Bureau carries with it an assignment that represents only research work or investigation. However, notwithstanding this, the salary compensation for the effective performance of the immediate responsibilities at field stations, is attractive, and the tour of daily duties furnishes opportunities for those so qualified to engage in the pursuit of minor meteorological, climatological and forecasting researches whenever possible.

The foregoing comments are submitted with the belief that young men who are interested in the science and practical application of meteorology to human welfare will find a field of opportunity and prospect in the Weather Bureau that can hardly be surpassed elsewhere in congeniality and advantage.

VALUES OF THE SOLAR CONSTANT, *1920–1922.*

By C. G. ABBOT and Colleagues.[1]

[Smithsonian Institution, Washington, D. C., March 29, 1923.]

INTRODUCTION.

Hitherto the Smithsonian Institution has promoted these researches on solar variation, as we may say, in faith. There were, to be sure, many fragmentary evidences, all pointing to the conclusion that the sun varies, and that its variations may be of importance for meteorology. But these variations are of so small a percentage range that it is only barely possible, by the most careful work in the most favorable climates, to make absolute determinations of the solar constant of radiation sufficiently accurate to reveal them. Evidences of solar variation collected in Volumes III and IV of the *Annals of the Astrophysical Observatory* seemed to have great probability. But the large expense, the sacrifice which the work cost, and the many years which we have devoted to it, combined to swell so heavy a debit account that no one of these individually hardly conclusive evidences, or even all of them together, could take away a load of deep anxiety. We could not help carrying in the back of our minds the misgiving lest this costly work should in the end prove wasted, except for the uninspiring result of proving a negative.

This is now past. We present the following results with confidence that they leave no reasonable doubt that the solar radiation varies, and that good work in well-established stations may be carried on with a continuously high-enough degree of accuracy to determine the variations. Confidence may now be assured that future observations at our two stations in the opposite hemispheres will accord even better than those made hitherto, and that they will disclose considerable variations of the sun. Arrangements are now completed to carry on these observations for several years.

This is our part. We think it will be an interesting and profitable task for meteorologists to examine what effects such solar variations produce on terrestrial weather conditions. Whether they will prove important forecasting evidences, the future will disclose.

THE NEW STATIONS.

Convinced of the unsuitability of Mount Wilson for a solar constant station to be occupied the entire year, inquiries were made through the United States Weather Bureau as to the most favorable station to be occupied in the United States. The desired qualities were (1) cloudlessness, (2) uniformity of sky, (3) high elevation above the surrounding country, (4) accessibility and habitability.

Professor Marvin, Chief of the United States Weather Bureau, very helpfully ordered a special research in connection with the matter. Two journeys were made by Mr. Edgar H. Fletcher, assistant observer at Phoenix, Ariz., to prospect for a suitable mountain location. He reported upon the following locations: Table Top Mountain and Montezumas Peak, near Maricopa, Ariz.; Black Peak, near Ajo, Ariz.; two peaks near Mohawk, Ariz.; the Chocolate Mountains, near Yuma, Calif.; San Jacinto Peak; the Calico Mountains, near Daggett, Calif.; Old Dads Mountain, near Bagdad, Calif.; Sugar-Loaf Peaks, near Barnwell, Calif.; Kessler Peak near Cima, Calif.; Crescent Peak near Crescent, Nev.; Mount Harqua Hala near Wenden, Ariz.

After consideration the stations Cima and Bagdad, Calif., and Wenden, Ariz., were selected as lying near accessible mountains which seemed most promising of those proposed. Chief Marvin caused daily observations of the amount and kinds of clouds, direction and velocity of the wind, and visibility of the mountains to be taken near Cima, Bagdad, and Wenden at the hours 7 and 9 a. m. noon and 3 and 5 p. m. These special observations were commenced in December, 1919, and continued until December, 1920. By June, 1920, it seemed clear that, on the whole, the station on Mount Harqua Hala, near Wenden, Ariz., had proved most advantageous of the mountain stations considered, and the Smithsonian Institution ordered the construction there of a suitable observing shelter. The original building, comprising two

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[1] My colleagues, F. E. Fowle, L. B. Aldrich, A. F. Moore, L. H. Abbot, and J. A Roebling, have each and all contributed so largely in different ways to these results that their names are entitled to coauthorship. It is only to avoid cumbrous citations that they are omitted in the heading.

Only less valuable and indispensable for the research has been the conscientious painstaking, and enthusiastic work of Messrs. A. Kramer, P. E. Greeley, F. A. Greeley Mrs. G. M. Bond, and Miss M. A. Neill.

We owe, besides, much to the help of the Weather Bureaus of the United States, Chile, and Argentina, the Chile Exploration Co., and to many citizens of Wenden Ariz., especially Mr. W. B. Ellison and Mr. J. E. Matteson.

stories, one below ground, the other above ground, is shown in Figure 1.

We published a summary of solar-constant values up to August, 1920, in Volume IV of the *Annals of the Astrophysical Observatory*. These included values from Mount Wilson, Calif., Hump Mountain, N. C., and Calama, Chile. In September, 1920, the solar-constant apparatus which had been for 15 years on Mount Wilson was removed to a new station on Mount Harqua Hala, Ariz., and in August, 1920, the apparatus which had been for two years at Calama was removed to a new station at Montezuma, Chile. The stations were both erected with funds supplied by Mr. John A. Roebling, who initiated the removal idea.

An account of the Montezuma station was published in the MONTHLY WEATHER REVIEW for December, 1921. Values observed there have been published at somewhat irregular intervals in the same journal. Hitherto nothing has been published from Mount Harqua Hala, although nearly 500 days of observation have occurred there. We have now completed the discussion of these results as far as September 20, 1922. At that date improved apparatus was substituted and the bolographic spectrum definition brought up to be equal to that at Montezuma. Beginning January 1, 1923, a revision of the computing data used at Montezuma was introduced so as to bring every detail of the work at the two places into accord. Hence, from January, 1923, we expect to find the results of the two stations in closer agreement than ever hitherto, but before publishing we shall withhold them for several months so as to redetermine the systematic errors which may have altered with these changes.

The present publication is an account of the selection and construction of Mount Harqua Hala station, a discussion of the systematic errors of its observations, and a summary of the results of both stations up to September 20, 1922, when the change was made in the apparatus at Harqua Hala.

In order to show the degree of cloudlessness of Wenden, as compared with other stations in the Southwest, we give here a table of values kindly furnished by Dr. H. H. Kimball from records of the Weather Bureau. It will be seen that for 12 months there were almost two-thirds of the days at Wenden when the sky did not exceed 10 per cent cloudy in the morning hours. Another feature which was regarded as favorable was the prevalence of dwarfed vegetation in the desert and upon Mount Harqua Hala. This would tend to keep down dust. The altitude of Mount Harqua Hala above sea level is 5,680 feet, and above the surrounding country, which lies about 2,000 feet above sea level, it is 3,700 feet. These values exceeded those of other mountains proposed. This also favors a clear sky as regards dust.

Readers should not lose sight of the fact that though the stations Yuma and Needles, Calif., show somewhat less cloudiness than Wenden, we were concerned to find isolated but accessible and habitable mountains of considerable height above the plain, so as to avoid surface dust. Such mountains were not available near Yuma and Needles.

TABLE 1.—*Number of days with cloudless sky.*

Station.	Time.	1920											1919	
		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Cima, Calif.	7 a. m.	9	6	9	13	21	22	17	18	18	13	15	9	170
Bagdad, Calif.	...do....	4	7	11	14	22	19	11	14	19	10	12	9	152
Wenden, Ariz.	...do....	8	6	17	18	25	20	19	17	18	11	16	11	186
Independence	5 a. m.	14	16	16	14	17	15	18	18	23	21	17	16	205
Needles, Calif.	...do....	26	22	24	27	28	24	26	21	24	23	27	29	301
Flagstaff, Ariz.	...do....	17	13	15	12	18	17	14	15	14	13	22	20	190
Phoenix, Ariz.	...do....	15	8	16	13	17	15	6	6	13	13	19	22	163
Yuma, Ariz.	...do....	22	17	19	25	27	25	20	18	22	25	29	23	272
Cima	9 a. m.	7	6	10	11	20	19	12	13	13	11	14	10	146
Bagdad	...do....	4	6	12	13	17	16	12	14	15	11	10	10	140
Wenden	...do....	6	6	13	19	24	19	17	17	18	13	16	11	179
Cima	Noon	8	5	8	12	18	15	12	7	13	9	14	7	128
Bagdad	...do....	4	4	10	9	15	16	10	9	16	12	5	6	116
Wenden	...do....	6	6	14	18	22	17	12	13	17	15	14	14	168
Independence	...do....	6	6	9	7	9	9	9	12	10	13	7	13	110
Phoenix	...do....	3	1	8	8	14	13	7	9	13	9	12	12	109
Yuma	...do....	8	7	18	25	25	24	18	17	20	22	19	14	217
Cima	3 p. m.	4	3	7	9	16	13	8	7	14	10	12	8	111
Bagdad	...do....	5	4	10	5	15	14	11	6	16	11	7	6	110
Wenden	...do....	6	5	15	20	21	20	13	8	17	18	16	14	173
Cima	5 p. m.	5	4	6	9	14	16	11	8	16	11	13	8	121
Bagdad	...do....	6	5	8	11	14	12	10	8	15	10	7	8	114
Wenden	...do....	8	9	13	20	21	24	15	9	23	18	23	14	197
Independence	...do....	7	7	7	7	6	5	9	5	6	12	7	11	89
Needles	...do....	11	9	15	17	18	20	20	22	22	16	17	20	207
Flagstaff	...do....	5	5	7	7	9	9	6	6	10	12	15	11	102
Phoenix	...do....	3	2	10	13	16	14	8	5	9	11	13	10	114
Yuma	...do....	5	4	17	19	21	23	15	16	17	17	19	14	187
Cima	Day	3	2	4	4	14	10	8	6	10	8	8	6	83
Bagdad	...do....	3	1	5	4	10	9	6	6	10	9	4	6	73
Wenden	...do....	3	5	8	15	19	17	10	7	13	10	12	9	128
Independence	...do....	4	4	4	3	4	4	5	4	3	8	6	9	58
Phoenix	...do....	3	0	6	4	12	9	4	4	5	6	8	10	71
Yuma	...do....	3	3	11	18	20	20	14	10	12	15	15	11	152
		1918												
Independence	Day	8	5	6	6	0	3	4	5	5	6	5	5	58
Phoenix	...do....	2	3	4	4	8	1	0	2	6	4	6	5	45
Yuma	...do....	13	12	8	16	14	7	8	7	12	12	13	15	137

TABLE 2.—*Number of days on which the cloudiness did not exceed 10 per cent.*

Station.	Time.	1920											1919	
		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Cima	7 a. m.	12	9	15	19	24	25	19	21	21	21	21	13	220
Bagdad	...do....	4	8	17	20	23	22	15	14	20	12	12	....	167
Wenden	...do....	11	7	22	22	29	23	25	20	22	14	20	17	232
Independence	5 a. m.	22	20	21	21	26	23	23	28	25	26	20	25	280
Needles	...do....	26	22	24	27	28	24	26	21	24	23	27	29	301
Flagstaff	...do....	18	15	17	19	22	22	21	20	20	14	22	20	230
Phoenix	...do....	16	12	20	22	29	22	22	21	27	19	23	23	256
Yuma	...do....	27	18	25	26	29	28	24	23	25	28	29	27	309
Cima	9 a. m.	9	7	13	19	20	21	17	16	17	14	19	15	187
Bagdad	...do....	4	10	16	19	19	17	13	14	17	12	10	....	151
Wenden	...do....	8	7	17	19	26	20	21	21	23	18	17	16	213
Cima	Noon	9	6	11	15	18	19	13	11	17	12	17	16	164
Bagdad	...do....	4	7	12	18	17	16	11	11	20	14	7	....	137
Wenden	...do....	7	9	17	20	22	22	17	20	23	17	16	15	205
Independence	...do....	13	16	14	23	19	15	23	23	21	20	12	19	218
Phoenix	...do....	10	9	18	21	24	20	25	26	25	15	16	21	230
Yuma	...do....	15	14	24	28	27	28	27	24	26	27	26	23	289
Cima	3 p. m.	5	4	9	14	17	16	11	8	17	11	16	14	142
Bagdad	...do....	6	5	13	15	16	18	12	8	18	14	18	....	143
Wenden	...do....	6	8	17	20	22	22	18	12	20	19	19	15	198
Cima	5 p. m.	9	4	10	16	17	20	14	11	19	14	19	16	169
Bagdad	...do....	8	5	12	15	16	13	10	11	16	12	7	....	125
Wenden	...do....	9	10	15	21	22	26	16	13	24	20	24	19	219
Independence	...do....	12	10	16	15	17	15	20	17	19	19	11	17	188
Needles	...do....	11	9	15	18	19	21	20	23	22	16	19	20	213

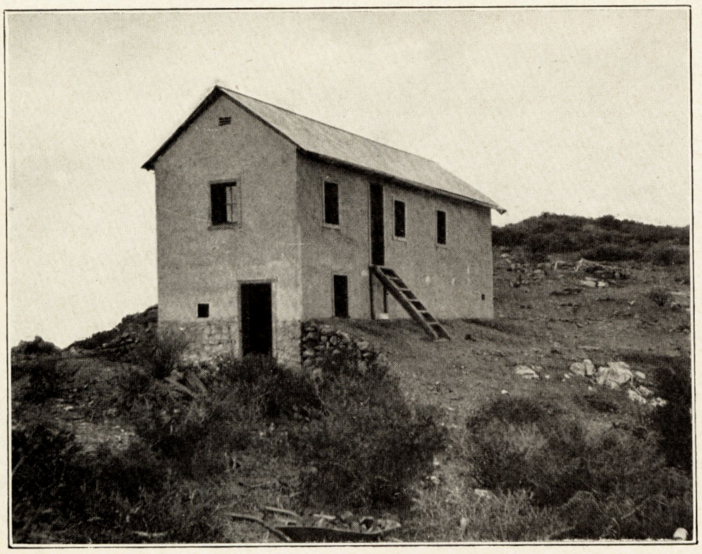

FIG. 1.—Smithsonian Observatory, Mount Harqua Hala, Ariz. Original condition.

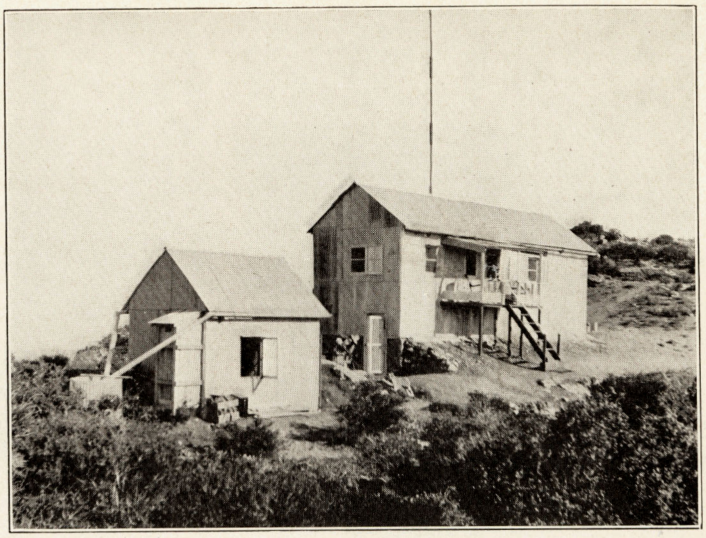

FIG. 2.—Smithsonian Observatory, Mount Harqua Hala, Ariz. Condition in 1922.

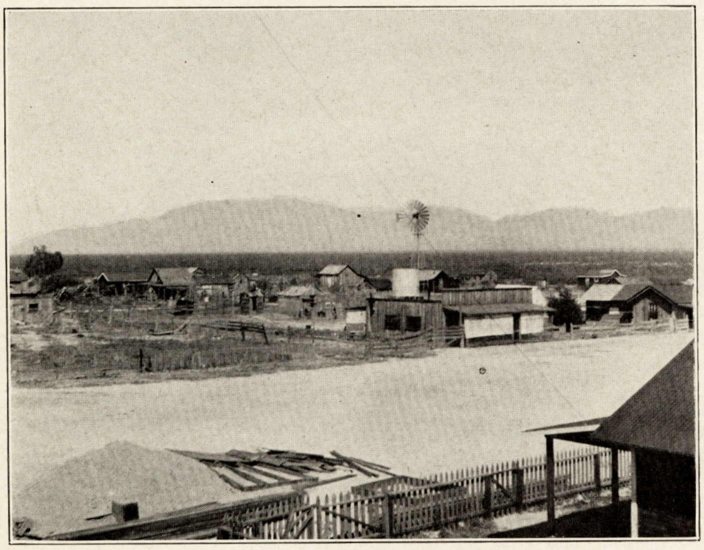

FIG. 3.—Wenden, Ariz., Mount Harqua Hala in distance.

FIG. 4.—Instruments, Mount Harqua Hala, Ariz. F. A. Greeley observing with pyrheliometer.

FIG. 5.—Observatory at Montezuma, Chile. (Cave near mountain summit.)

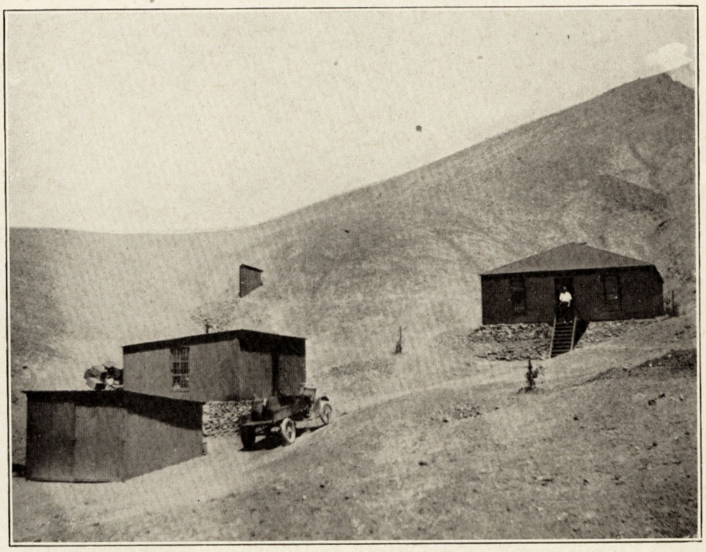

FIG. 6.—Dwelling at Montezuma, Chile.

TABLE 2.—*Number of days on which the cloudiness did not exceed 10 per cent*—Continued.

Station.	Time.	1920											1919	
		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Flagstaff	5 p. m.	8	7	8	13	13	16	12	10	15	14	17	13	146
Phoenix	do	9	8	13	16	20	19	12	10	18	15	19	18	177
Yuma	do	15	13	27	25	28	26	23	23	23	26	23	23	275
Cima	Day	4	3	8	10	16	12	10	6	14	9	12	7	111
Bagdad	do	4	4	8	9	11	11	7	6	11	10	5	....	86
Wenden	do	3	5	10	19	20	19	12	8	17	12	14	10	149
Independence	do	9	9	9	12	12	13	14	17	15	13	9	14	146
Phoenix	do	6	4	10	13	19	17	11	10	17	12	14	15	148
Yuma	do	14	10	20	23	25	24	21	16	21	23	21	21	239
		1918												
Independence	Day	19	10	15	14	6	13	15	18	12	11	11	10	154
Phoenix	do	14	12	10	14	13	11	6	8	16	17	13	15	149
Yuma	do	17	15	10	21	19	20	13	10	16	18	19	22	200

In consequence of the rapid rise and abrupt approaches to the summit of Mount Harqua Hala, there are no means of access except a steep and narrow trail, difficult to use for packing parcels of large size or weight. On this account it seemed best to construct the building (40 by 10 feet) of adobe bricks, which were made on the summit, with sand, mud, and water, all collected within a mile of the building. The walls are 12 inches thick. The lower rooms for the instruments are almost entirely below the level of the ground except at the southern end, and here the dirt and stones removed at the other end were heaped up against the walls so as practically to make all but the southern wall of the lower story under ground. This, of course, is highly favorable to a constant temperature for the instruments.

The station on Mount Harqua Hala was first occupied by Messrs. C. G. Abbot and L. B. Aldrich about September 25, 1920. Observations were begun there on October 3, 1920. Since then the observations have been carried on as follows:

Date.	Observer.
October 3, 1920–January 21, 1921	C. G. Abbot. F. A. Greeley.
January 21–April 22, 1921	L. B. Aldrich. F. A. Greeley.
April 22, 1921–Present	A. F. Moore. F. A. Greeley.

During Mr. Moore's administration, Mrs. Moore not only has assisted occasionally in computations, but has always cooperated with enthusiasm for the morale of the station as well as attending to the household work and keeping the place attractive and homelike.

Many improvements have been made through the kindness of Mr. John A. Roebling. Heavy rains washed away part of the adobe walls, so that on Mrs. Moore's suggestion, they were sheathed with sheet metal. A small shop was erected. Water tanks of cement, having a total storage of 2,000 gallons, were built by Moore and Greeley and connected to the roofs to catch the rain and snow water. An ingenious shower bath, of Mr. Moore's design, makes summer heat more tolerable. A sulphur-dioxide refrigerating plant called the "Kelvinator" aids to keep food, and make it palatable. Wireless telephone devices enable the staff to "listen in" as far east as Schenectady on favorable occasions. A wire telephone to Wenden is of the very greatest use. At the foot of the mountain trail is a small garage to keep the Ford automobile used to transport supplies over the 11 miles to and from Wenden. Mr. Ellison, a mining prospector, has been an exceptionally kind neighbor, and makes regular trips to Wenden for mail and supplies.

THE SOLAR OBSERVATIONS.

After making many days of "long method" observations to determine the relations of atmospheric transmission to values of the "Function" (which is found by dividing the pyranometer measurement of sky radiation near the sun by the value $\rho/\rho_{s.c.}$ as explained in our account of Chilean observations) "Function transmission curves" were plotted for Harqua Hala.[2] The air masses chosen for these curves were 1.3, 2, and 2.7. As was the case at Calama and Montezuma, it was impossible to determine these curves satisfactorily at high values of the "Function," such as attend the most humid days of summer. For at such times the atmosphere almost never remains uniformly transparent long enough to determine its transmission coefficients by the "long method." Accordingly, we expected that systematic errors would be found to be associated with the work, depending on the values of the "Function" or on the values of "precipitable water" in the atmosphere. For this reason we withheld the Harqua Hala work from publication for two years, until so large a mass of data accumulated that it could be treated statistically to determine and correct these systematic errors.

It proved best to determine the errors primarily as functions of "precipitable water." But when this was done, slight additional corrections were found desirable at very large and very small values of the "Function." Our procedure has been first to group all the solar constant values at each of the three air masses, 1.3, 2, 2.7, separately, between limits of "precipitable water" as determined from the bolographs by Fowle's method.[3] It seemed desirable to eliminate changes depending on the monthly march of the solar constant before taking means of these groups. Having already found by similar studies that no sensible corrections are needed at Montezuma, we took the monthly mean values derived at Montezuma [4] as indicative of the march of the solar constant. They are as follows:

TABLE 3.—*Corrections to constant sun.*

	1920			1921			
	October.	November.	December.	January.	February.	March.	April.
Number of days	20	24	20	9	7	12	16
Mean value	1.945	1.948	1.957	1.955	1.956	1.949	1.944
Correction to 1.950	+.005	+.002	−.007	−.005	−.006	+.001	+.006

	1921							
	May.	June.	July.	August.	September.	October.	November.	December.
Number of days	12	17	17	....	5	13	15	12
Mean value	1.946	1.939	1.947	....	1.953	1.956	1.947	1.952
Correction to 1.950	+.004	+.011	+.003	0.000	−.003	−.006	+.003	−.002

[2] See Annals Astrophysical Observatory, Vol. IV, figs. 6 and 7.

[3] See Annals, Astrophysical Observatory, Vol. III, p. 171.

[4] These values differ slightly from those given in Table 5 on account of including some days omitted in that table and also smoothing some months.

TABLE 3.—*Corrections to constant sun*—Continued.

	1922							
	January.	February.	March.	April.	May.	June.	July.	August.
Number of days...	19	11	16	13	4	11	8	10
Mean value........	1.944	1.950	1.938	1.931	1.925	1.911	1.911	1.918
Correction to 1.950.	+.006	.000	+.012	+.019	+.025	+.039	+.039	+.032

From these data we felt that we could approximately eliminate from our Harqua Hala groups long continued departures of the solar constant by altering each individual value by the appropriate amount given in the last line of the preceding table. Thus all values for January, 1921, were decreased by 0.005, while those for July, 1921, were increased by 0.003, etc. This correction designed to eliminate the general march of solar variation having been made, the mean values of the solar constant corresponding to each group were found and plotted against mean precipitable water for the same group. Thus were determined the corrections to be applied to reduce solar constant values to a uniform amount of precipitable water. The results were quite definite in trend and on the whole satisfactory.

However it was noticed that within each group there was a considerable range of "Function" values. Hence, the data in each "precipitable-water" group were regrouped with reference to the value of the "Function" which prevailed. Upon examination of the plots resulting, it appeared that certain small additional corrections, never reaching so much as 1 per cent, and seldom as much as one-half per cent, should be applied to eliminate residual errors depending on the "Functions," and not fully removed by the first process.

Having in these ways found the best values of the corrections necessary to remove the influences of water vapor and "Function" value on solar constant work at Harqua Hala, one further systematic correction was required. The Harqua Hala observations proved to be on the whole a little smaller than those made at Montezuma. In order to obtain a homogeneous system so that values which were observed alone at Harqua Hala, or alone at Montezuma, would be comparable with those observed at the other station, or with mean values from both, a small horizontal increase was made in the Harqua Hala values to bring them up to the scale of Montezuma. This was a little over 1 per cent.

We now returned to the original observations at Harqua Hala (not modified to allow for solar changes), and taking into account the air mass, the "precipitable water," and the "Function" prevailing, we applied to each value independently the corrections statistically determined, as above described, from the discussion of them all. Readers will note that these corrections do not depend on Montezuma work except in two ways. First, the apparent monthly march of the solar constant has been eliminated from the water-vapor corrections at Harqua Hala by considering Montezuma monthly mean values. Second, a slight horizontal increase of all Harqua Hala observations has been made to bring about an homogeneous final scale of values. Obviously neither of these modifications can have brought to bear any influence from Montezuma on the *variability* of the sun as determined at Harqua Hala.

The following tables give, besides the individual results at both stations, their weighted means, and the final weighted mean. In weighting, we have considered the observers' notes as to the sky conditions prevailing, the number of observations, their agreement, the air mass (giving large air masses half weight), and have omitted from final means, or given small weight, the determinations which were unsatisfactory at one of the stations. The grades given mean "satisfactory," "less satisfactory," and "unsatisfactory."

We have made no use of "long method" values at Harqua Hala, except for determining "Function transmission curves." We consider them individually so much less accurate than "short-method" values, because they are influenced by clearing up or hazing up of the atmosphere, while short method values are not, that to include them in the mean values would injure the work. The observers at Montezuma have been accustomed to give "long method" values half weight. We have thought it best not to alter their "weighted mean" values already published in the MONTHLY WEATHER REVIEW, but have modified the grade assigned.

In a preliminary Table 7 we give values for Montezuma observed in August and September, 1920. The columns are identical in character with columns 1 and 7 to 12 of the main table described below.

The main Table 8 contains 15 columns. First, date; second, third, and fourth are the decimal parts of Harqua Hala solar-constant values derived by the short method from observations nearest 1.3, 2, and 2.7 air masses, respectively; fifth, gives the weighted mean of these, and sixth its grade. Columns 7, 8, 9, and 10 are similar Montezuma values, nearest the air masses 1.5, 2, 2.5, and 3, which were adopted in drawing the "Function transmission curves" there. Column 11 gives long-method values at Montezuma. Column 12 gives the weighted mean of Montezuma values, and column 13 its grade. Column 14 gives the finally adopted solar constant value for the day and column 15 its grade.

In cases where more than one observation was made near one of the standard air masses only the mean value of them is given. A small figure, like an exponent, indicates for this mean value how many observations it represents.

We have been particularly interested to ascertain how closely the observations of the two stations duplicate each other. We have, as said above, applied a small horizontal increase at Harqua Hala to bring the two series to the same scale. We hope that it will prove that the magnitude of this, and of the corrections depending on humidity, will be reduced, now that the work has been brought to an identical basis at the two stations. A comparison of values, however, will show the magnitudes of the accidental experimental and local atmospheric errors in the work of 1920 to 1922. In making such a comparison, we have felt justified in rejecting all days marked unsatisfactory at either station. Those rejected include a number of days of January, February, and March, 1922, when an accident to the pyranometer at Montezuma threw back the daily work there to single long-method determinations. There remain in common observations distributed as shown in the following table, which gives differences H. H.—Montezuma.

TABLE 4.—*Mean differences (H. H.—Montezuma).*

	1920.			1921.				
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Number of plus....	3	6½	2	3	2	1½	4	3
Number of minus..	3	3½	1	0	2	1½	2	1
Mean of plus.......	0.0083	0.0126	0.0055	0.0367	0.0200	0.0040	0.0097	0.0123
Mean of minus.....	.0063	.0200	.0110	....	.0080	.0247	.0135	.0080
General mean......	.0073	.0153	.0073	.0367	.0130	.0143	.0110	.0112

	1921.						
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Number of plus............	6	0	1	1	3	4	2
Number of minus..........	8	2	0	2	3	2	5
Mean of plus................	0.0107	....	0.0030	0.0050	0.0143	0.0139	0.0060
Mean of minus..............	.0122	0.0050	....	.0260	.0087	.0090	.0172
General mean...............	.0116	.0050	.0030	.0190	.0115	.0122	.0140

	1922.								Total.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	
Number of plus....	6	1	2	2	1	6	2	1½	63½
Number of minus..	4	0	1	2	1	3	3	1½	51½
Mean of plus.......	0.0085	0.0170	0.0175	0.0180	0.0090	0.0183	0.0100	0.0127	0.0137
Mean of minus.....	.0175	....	.0060	.0230	.0010	.0030	.0197	.0087	.0124
General mean......	.0126	.0170	.0137	.0205	.0050	.0132	.0158	.0107	.0132

According to this summary, the numbers and averages of plus and minus deviations are nearly equal. There is no certainly discernible monthly march tending to alter the prevailing sign of difference during the year, notwithstanding that the two stations are on opposite sides of the Equator. The mean difference, without regard to sign, is approximately 0.68 per cent of the solar constant. Dividing this by $\sqrt{2}$ and multiplying the quotient by 0.84, the probable accidental error of a single good day's determination at one station comes out approximately 0.41 per cent. We consider this satisfactory, but we hope it will be found that the new work to follow January, 1923, will give a still closer accord between the two stations.

As the purpose of the work is primarily to reveal, confirm, and evaluate variations of the solar constant, we must look with highest interest on a comparison designed to indicate if the two stations agree in pointing out intervals of the high and low values. The observations are so broken, especially in Chile, that consecutive plotting is an unsatisfactory means of comparison. However, we may point out the periods 1920, November 1 to 18; 1921, January 8 to 16, February 11 to March 4, April 1 to 17, November 17 to December 10; 1922, January 15 to 19, February 12 to 22, as prevailingly high, and the periods 1921, June 4 to 13, October 8 to 22;

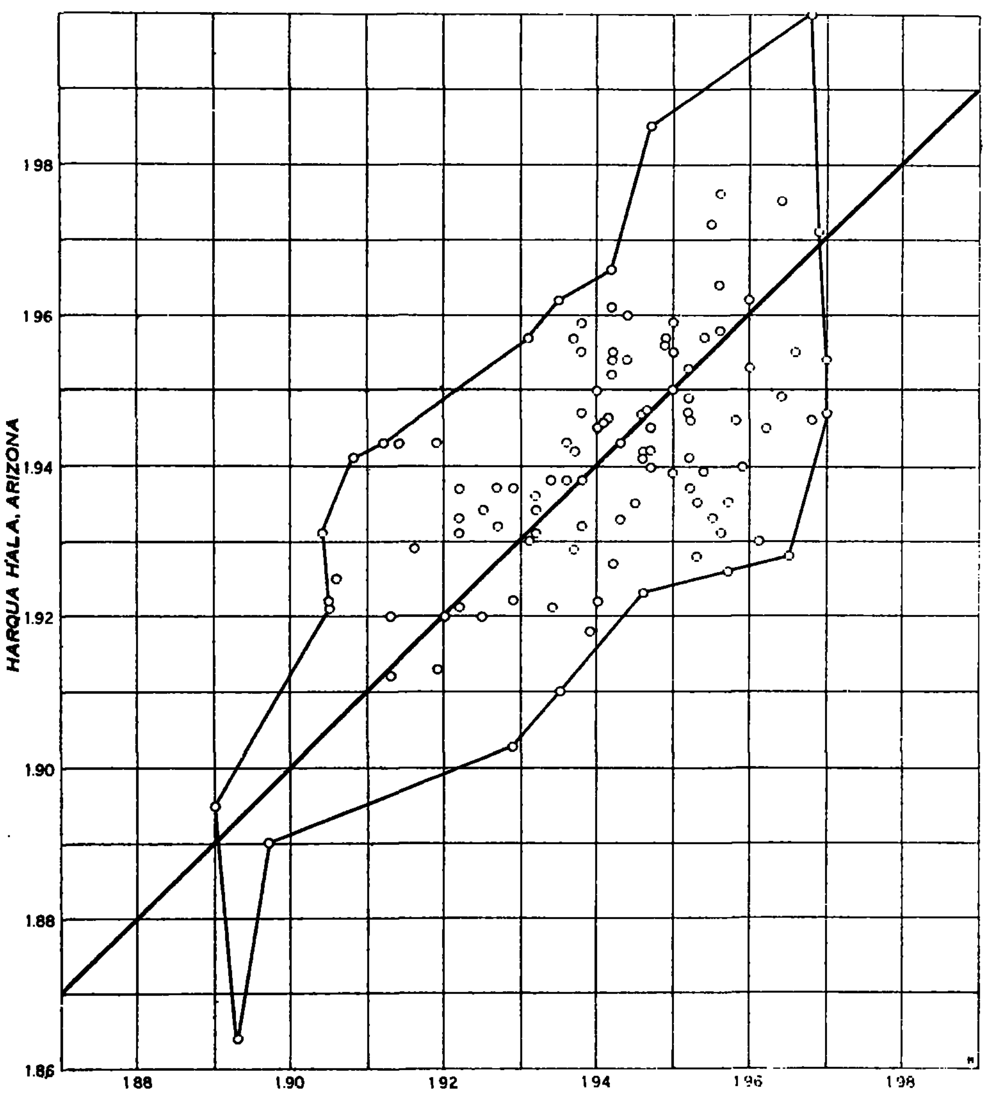

FIG. 7.—Daily duplicate observations of the solar constant at Mount Harqua Hala, Ariz (ordinates), and Montezuma, Chile (abscissæ).

1922, January 4 to 12 and March 1 to the end of our period in September, as prevailingly low at both stations.

A more satisfactory method of comparison, in view of the broken character of the data, consists in plotting the duplicate daily observations at the two stations as abscissæ and ordinates, respectively. In such a plot real solar variations stretch out the data along a straight line at 45° inclination. We give such a plot in Figure 7.

We also give in the following Table 5 the monthly mean values at each station. We have omitted values graded "Unsatisfactory." It is not to be expected that these will accord as well as they would if no days were lacking, because they do not coincide in time, many days not being common. However, the general trend is closely the same, as Figure 8 shows.

The average monthly mean difference, H. H.—Montezuma, is about 0.3 per cent. It is very reassuring not to perceive in the plots a definite tendency to separation at particular parts of the year, such as would indicate a yearly periodicity due to erroneous observations. For it should be recalled that summer of one station is winter of the other. It would not have been surprising had there been residual errors due to temperature or to prevailing altitude of the sun above the horizon, and had these been of importance they would have worked oppositely in the two hemispheres to produce notable discrepancies.

Readers will observe that the rapid fall of the solar radiation from November, 1921, to the close of the period under discussion is a very outstanding feature of the

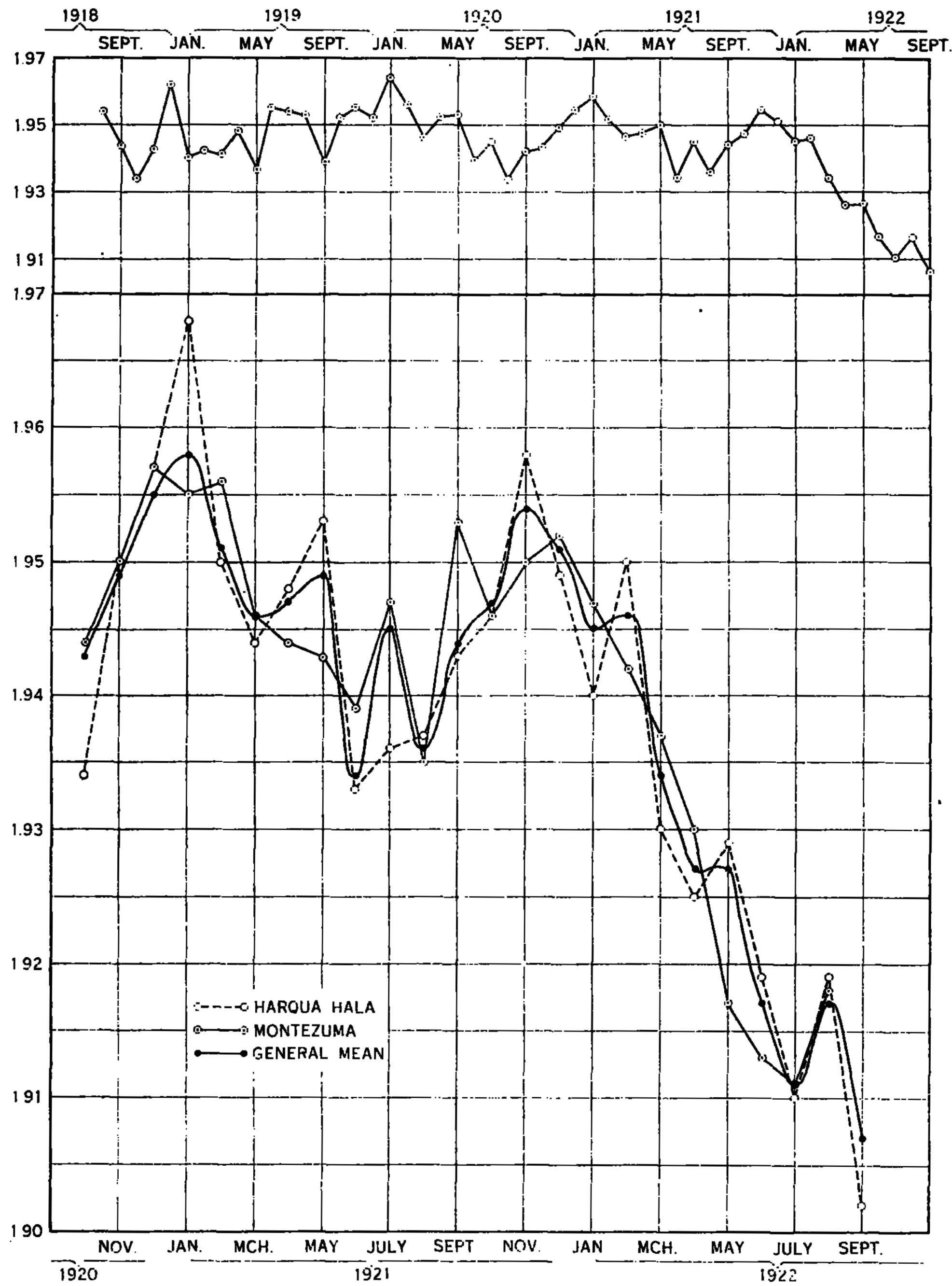

FIG. 8.—Monthly mean values of the solar constant compared.

results. In order to show how very unusual and remarkable this is, we give in a small-scale plot at the top of the figure the curve of monthly mean values from August, 1918, when the Chilean station was established, to September, 1922, the close of the comparison we are making. The Calama values are given in Table 6. It is apparent that in these four years there has never been any solar change so marked and extraordinary as the one just mentioned, nor have our observations at Mount Wilson indicated a parallel to it, with the possible exception of 1913. This statement, however, is subject to the qualification that the Mount Wilson values never covered more than half of the year, and frequently less.

Unpublished observations at Arizona and Chile since September, 1922, indicate that the low solar values continued and perhaps became still more pronounced. Whether this has an important bearing on the unusual weather conditions of recent months will be for meteorologists to decide.

TABLE 5.—*Monthly mean values compared.*

["Unsatisfactory" values omitted, U+ retained.]

	1920			1921			
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
No., Harqua Hala	11	10	3	9	17	9	15
No., Montezuma	20	25	21	9	7	13	16
No., in mean	25	25	22	14	20	18	26
Mean, Harqua Hala	1.934	1.950	1.957	1.968	1.950	1.944	1.948
Mean, Montezuma	1.944	1.950	1.957	1.955	1.956	1.946	1.944
Harqua Hala-Montezuma	0.010	0.000	0.000	0.013	−0.006	−0.002	0.004
General mean	1.943	1.949	1.955	1.958	1.951	1.946	1.947

	1921							
	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
No., Harqua Hala	13	20	5	12	25	19	17	10
No., Montezuma	12	17	17	1	5	11	14	12
No., in mean	22	23	21	11	27	23	24	15
Mean, Harqua Hala	1.953	1.933	1.936	1.937	1.943	1.946	1.958	1.949
Mean, Montezuma	1.943	1.939	1.947	1.935	1.953	1.946	1.950	1.952
Harqua Hala-Montezuma	0.010	−0.004	−0.011	0.002	−0.010	0.000	0.008	−0.003
General mean	1.949	1.934	1.945	1.936	1.944	1.947	1.954	1.951

	1922								
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.[1]
No., Harqua Hala	13	8	12	17	20	23	18	9	13
No., Montezuma	18	9	11	11	5	10	8	10	2
No., in mean	21	16	20	24	24	24	19	15	13
Mean, Harqua Hala	1.940	1.950	1.930	1.925	1.929	1.919	1.910	1.919	1.902
Mean, Montezuma	1.947	1.942	1.937	1.930	1.917	1.913	1.911	1.918	1.930
Harqua Hala-Montezuma	−0.007	0.008	−0.007	−0.005	0.012	0.006	−0.001	0.001	−0.028
General mean	1.945	1.946	1.934	1.927	1.927	1.917	1.911	1.917	1.907

[1] This month is incomplete. A change in apparatus was made at Harqua Hala after Sept. 20, so that the table closes with that day. Only two satisfactory observations being reported from Montezuma, and these quite out of the general trend, the large difference between the stations should be discounted.

Average monthly deviation (Harqua Hala-Montezuma) without regard to sign, 0.0057, or 0.3 per cent. Range of solar variation in monthly means 2.5 per cent.

General means (Montezuma alone):
August, 1920, No. 27, value, 1.934.
September, 1920, No. 25, value, 1.942.

TABLE 6.—*Monthly mean values at Calama, Chile.*

	1918					1919		
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Number of observations	27	18	24	23	19	19	20	16
Mean value	1.954	1.944	1.934	1.943	1.962	1.910	1.942	1.941

TABLE 6.—*Monthly mean values at Calama, Chile*—Continued.

	1919								
	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Number of observations	27	27	22	27	30	28	20	25	24
Mean value	1.948	1.937	1.955	1.954	1.953	1.939	1.952	1.953	1.952

	1920						
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
Number of observations	25	19	29	30	29	23	21
Mean value	1.964	1.956	1.946	1.952	1.953	1.939	1.945

We reserve further comment on the results. We hope they will prove valuable to meteorologists. As we have intimated already, the present outlook warrants the hope that more numerous and more concordant observations will be available from January 1, 1923. Arrangements have been made to continue daily observations at both stations until July, 1925, when it will be earnestly considered whether they should continue longer, and if so, under what auspices.

TABLE 7.—*Montezuma values, August–September, 1920.*

Date.	Solar constant.						
	1.5	2.0	2.5	3.0	Long.	Mean.	Grade.
1920.							
Aug. 1							
2							
3					919	1.919	S
4					922	1.922	S
5					927	1.927	S
6		962				1.962	S−
7					932	1.932	S+
8		919	926			1.922	S−
9		944	939	928		1.937	S
10		933	915			1.922	S−
11		923	924	927		1.925	S
12					932	1.932	S+
13					979	1.979	S+
14		921				1.921	S−
15			915	926		1.920	S−
16							
17					968	1.968	S+
18			943	942		1.943	S−
19		942	932	946		1.940	S
20					924	1.924	S
21					940	1.940	S
22		939	951			1.945	S
23					942	1.942	S+
24		897	905			1.901	S−
25							
26	949	939				1.945	S
27					928	1.928	S+
28					951	1.951	S+
29					915	1.915	S
30					921	1.921	S
31					923	1.923	S
Sept. 1					939	1.939	S+
2					956	1.956	S
3	957	947				1.952	S
4							
5		954	927			1.936	U+
6	870	867	875	897	901	1.885	S−
7					951	1.951	S
8					964	1.964	S
9	943		942	950	918	1.945	S+
10					953	1.953	S
11		926	926			1.926	S
12					943	1.943	S+
13		949	927	949	916	1.940	S
14					945	1.945	S+
15			950	969		1.961	S−
16					937	1.937	S
17					951	1.951	S+
18					948	1.948	S
19	[2] 932					1.932	S
20							
21							
22	947	936	935			1.937	S
23					961	1.961	S
24					946	1.946	S
25					941	1.941	S
26		944	934	938		1.939	S
27					914	1.914	S−
28					952	1.952	S
29							
30							

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922.*

Date		H. H. solar constant. 1.3	2.0	2.7	Mean.	Grade.	Montezuma solar constant. 1.5	2.0	2.5	3.0	Long.	Mean.	Grade.	Weighted mean.	Grade.
1920. Oct.	1										938	938	S	1.938	S
	2							928	930	933	912	928	S	1.928	S
	3														
	4	944	941		942	S					946	946	S	1.944	S
	5	[2]981			981	U					951	951	S−	1.951	S−
	6							931	928	918	937	929	S	1.929	S
	7								908	925		917	S−	1.917	S−
	8	958	946		952	S	[2]942					942	S−	1.947	S
	9						964	957				959	S	1.959	S
	10	896	975		935	U	[2]947					947	S−	1.947	S−
	11							956	957	959	948	956	S	1.956	S
	12			980	980	U		940	929	954		943	S−	1.943	S−
	13		902	880	891	U								1.891	U
	14	936	957	958	949	S								1.949	S
	15	959	980	979	971	S					969	969	S	1.970	S
	16	936	960	945	947	S					952	952	S	1.950	S
	17							933	944	950		944	S−	1.944	S−
	18	951	960		955	S−		943	939	943		942	S−	1.948	S−
	19														
	20														
	21			971	971	U		940	948	955	954	951	S−	1.951	S−
	22	937	939	923	935	S	[2]945					945	S	1.940	S
	23	[2]933			933	S								1.933	S
	24	914	918	856	916	S−								1.916	S−
	25	902	928	911	914	S	954					954	U	1.934	S−
	26	946	964	958	955	S								1.955	S
	27														
	28							[2]941	943			942	S−	1.942	S−
	29										948	948	S−	1.948	S−
	30						[2]931					931	S−	1.931	S−
	31														
Nov.	1										963	963	S	1.963	S
	2	935	933	919	931	S	953	958				956	S	1.943	S
	3	973	982	973	976	S		960	951			956	S	1.966	S
	4								938	957		952	S−	1.952	S−
	5		963		963	U	951	936	946		974	950	S	1.954	S
	6						955	950	940			948	S	1.948	S
	7							952	941			945	S−	1.945	S−
	8	949	960	957	955	S		949	951			950	S	1.952	S
	9						944	947	948			947	S	1.947	S
	10	949	958	968	956	S−	940	[2]953				949	S−	1.952	S
	11						952	[2]956				955	S	1.955	S
	12								944	928		938	S−	1.938	S−
	13		953	944	950	S	952	949		950	950	950	S+	1.950	S+
	14		[2]966		966	S−	[2]942					942	S	1.953	S
	15										964	964	S	1.964	S
	16		940	924	934	S−		929	918			925	S−	1.929	S
	17		[2]949		949	S−	[2]964					964	S−	1.956	S
	18	941	981		961	S−		936	941	947		942	S	1.951	S−
	19														
	20		999		999	U								1.999	U
	21			926	926	S−	957					957	S−	1.941	S−
	22						953	928				945	S−	1.945	S
	23						[2]956					956	S	1.956	S
	24								931	937		935	S	1.935	S
	25							[2]949				949	S−	1.949	S−
	26								935	939		938	S−	1.938	S−
	27							[2]938				938	S−	1.938	S−
	28														
	29														
	30														
Dec.	1														
	2														
	3						[2]944					944	S	1.944	S
	4						968	964				966	S	1.966	S
	5							956	955	974	936	955	S	1.955	S
	6							950	963	959		959	S−	1.959	S−
	7							959	951	953		954	S	1.954	S
	8							945	973	969	949	959	S	1.959	S
	9														
	10						[2]965					965	S−	1.965	S−
	11							979	976	961	984	977	S	1.977	S
	12							960	956			959	S	1.959	S
	13							973	954	945		957	S−	1.957	S−
	14							945	946	948		946	S	1.916	S
	15		952	962	957	S−		942	954	945	971	949	S	1.953	S
	16						952	954				953	S	1.953	S
	17		907		907	U	964	960				962	S	1.962	S
	18						962	948				954	S	1.954	S
	19		[2]916		916	U+	968	950				959	S−	1.959	S−
	20								959	941		950	S	1.950	S
	21		881	891	886	U								1.886	U
	22						962					962	S−	1.962	S−
	23														
	24														
	25						944					944	S−	1.944	S−
	26														
	27														
	28	938	911	926	925	U+						925	U+	1.925	U+
	29														
	30	939	966	973	957	S	954	955				954	S	1.956	S
	31	962	947	958	955	S			972	959		966	S	1.960	S
1921. Jan.	1	957	957	958	957	S								1.957	S
	2														
	3														
	4						[2]968					968	S−	1.968	S−
	5						967	957				964	S−	1.964	S−
	6						[3]931					931	S	1.931	S
	7							954	954			954	S	1.954	S
	8	015	023	019	021	S		951	959			954	S	1.987	S−

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922*—Continued.

Date		H. H solar constant. 1.3	2.0	2.7	Mean.	Grade.	Montezuma solar constant. 1.5	2.0	2.5	3.0	Long.	Mean.	Grade.	Weighted mean.	Grade.
1921. Jan.	9														
	10	986	016	994	000	S−	968					968	S	1.984	S
	11														
	12		[2]940	948	943	S								1.943	S
	13		[2]969		969	S								1.969	S−
	14		[2]979	967	975	S	964					964	S−	1.970	S
	15						[2]962					962	S	1.962	S
	16		968		968	U								1.968	U
	17														
	18										932	932	S−	1.932	S−
	19	008	020	039	019	U								2.019	U
	20			949	949	U								1.949	U
	21		948		948	U								1.948	U
	22														
	23														
	24		[2]962	950	960	S−								1.960	S−
	25		960		960	U								1.960	U
	26														
	27														
	28														
	29		[2]948	935	944	S−								1.944	S−
	31		940		940	S−								1.940	S−
Feb.	1	924	921	923	923	S								1.923	S
	2		[2]964		964	S−								1.964	S−
	3		943		943	S−								1.943	S−
	4		852		852	U									
	5														
	6	940			940	S−								1.940	S−
	7														
	8		[2]943	934	940	S								1.940	S
	9														
	10		011		011	U									
	11	948	966	960	958	S	[2]956					956	S−	1.957	S
	12		990	974	985	S−	947					947	S−	1.966	S−
	13	957	971	942	960	S								1.960	S
	14	893			893	U									
	15	958	[2]961		960	S								1.960	S
	16	964	962	954	961	S								1.961	S
	17	953	958	954	955	S								1.955	S
	18	944	952	950	948	S−								1.948	S−
	19	938	913	930	926	S								1.926	S
	20	932			932	U								1.932	U
	21						[2]959					959	S−	1.959	S−
	22	944	943	967	948	S								1.948	S
	23	927	955	950	943	S−								1.943	S−
	24	928	951	946	941	S	[2]946					946	S	1.944	S
	25	942	964	954	953	S	[2]960					960	S	1.957	S
	26						[2]955					955	S	1.955	S
	27														
	28						[2]972					972	S−	1.972	S−
Mar.	1	969	969		969	U+	[2]963					963	S−	1.966	S
	2	938	945	945	942	S	954					954	S−	1.948	S
	3		991		991	U	[2]959					959	S−	1.959	S−
	4	999	014		007	U		945		962		956	S−	1.956	S−
	5	919	882	848	919	U−		943	910			943	S−	1.943	S−
	6		912		912	U	[2]946					946	S−	1.946	S−
	7		930	926	929	U	[2]952					952	S−	1.952	S−
	8	902	912	869	908	U									
	9														
	10						957					957	S−	1.957	S−
	11														
	12														
	13						949					949	S−	1.949	S−
	14							868				868	U		
	15														
	16	945	977	949	959	S−								1.959	S−
	17	908	920	908	913	S	[2]950					950	S−	1.925	S−
	18							[2]915				915	S	1.915	S
	19	998			998	U−	[2]948					948	S−	1.948	S−
	20														
	21														
	22	003			003	U−									
	23	941	938	906	940	S−								1.940	S−
	24	892	869		881	U									
	25		878		878	U−									
	26	946			946	U									
	27	922	915	926	920	S−								1.920	S−
	28	927	942	964	940	S−								1.940	S−
	29	941	981	949	959	S−								1.959	S−
	30														
	31	958	956	955	951	S								1.951	S
Apr.	1						[2]948					948	S−	1.948	S−
	2						957					957	S−	1.957	S−
	3														
	4														
	5						965					965	S−	1.965	S−
	6	927	936	916	928	S	953					953	S−	1.940	S−
	7	942	936	924	936	S								1.936	S
	8	[2]872			872	U	[2]950					950	S	1.950	S
	9	894			894	U	[2]950					950	S−	1.950	S−
	10	951	960	963	957	S	[2]931					931	S−	1.944	S−
	11														
	12	933			933	S−		923	917	926		922	S	1.927	S
	13	853													
	14						[2]956					956	S−	1.956	S−
	15	946	941	953	945	S	[2]947					947	S−	1.946	S
	16						[2]946					946	S−	1.946	S
	17	950	955	955	953	S	[2]952					952	S−	1.952	S
	18						[2]945					945	S−	1.945	S−
	19							934	908			920	S−	1.920	S−
	20		966	971	968	S−								1.968	S−

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922*—Continued.

		H. H. solar constant.					Montezuma solar constant.							Weighted mean.	Grade.
		1.3	2.0	2.7	Mean.	Grade.	1.5	2.0	2.5	3.0	Long.	Mean.	Grade.		
1921.															
Apr.	21								921			921	S−	1.921	S−
	22	[2]956			956	S								1.956	S
	23	[2]919			919	S								1.919	S
	24	[2]933			933	S−								1.933	S−
	25		[2]947		947	U+	946					946	S−	1.946	S
	26	[2]944			944	S−								1.944	S−
	27			[2]988	988	S−								1.988	S−
	28	[2]951			951	S−								1.951	S−
	29		[2]962		962	S−								1.962	S−
	30		[2]945		945	S−								1.945	S−
May	1		958		958	S−								1.958	S−
	2	950			950	S								1.950	S−
	3	947			947	S−	[2]946					946	S−	1.946	S
	4						[2]950					950	S	1.950	S
	5								933			933	S−	1.933	S−
	6							[2]950				950	S	1.950	S
	7														
	8	963			963	U	[2]955					955	S	1.955	S
	9			972	972	U	949	938				944	S	1.944	S
	10	962			962	U+								1.962	U+
	11														
	12	948			948	S−								1.948	S−
	13		964		964	S−								1.964	S−
	14	893			893	U	944	938				941	S	1.941	S
	15		954	904	929	S−		[2]937				937	S	1.934	S−
	16		[2]938		938	S−								1.938	S−
	17														
	18		963	[2]945	957	S								1.957	S
	19		963	[2]969	963	S								1.963	S
	20														
	21								871	863		868	U−		
	22	031			031	U−		[2]937				937	S	1.937	S
	23	[2]962			962	S−	[2]935					935	S	1.948	S−
	24														
	25	958	954	973	959	S	[2]950					950	S	1.954	S
	26			987	987	U								1.987	U
	27	954	983		968	U								1.968	U
	28	950	966		958	U	941					941	S−	1.941	S−
	29	[2]951			951	S−								1.951	S−
	30		953		953	U								1.953	U
	31	809	783		796	U−									
June	1														
	2														
	3														
	4		943		943	S−	[2]943					943	S	1.943	S
	5	908	904	881	901	S−								1.901	S−
	6	971	979		974	U								1.974	U
	7	944	941	946	943	S				914		914	S−	1.928	S−
	8	929	947		938	S		[2]938				938	S	1.938	S
	9	952	943		947	S	951	932	914	928	967	938	S	1.942	S
	10		906	914	910	S−								1.910	S−
	11	[2]922			922	U+		[2]929				929	S	1.926	S
	12														
	13									937		937	S−	1.937	S−
	14														
	15														
	16	938	945		941	S−								1.941	S−
	17	949	941	927	941	S								1.941	S
	18		934	949	939	S−	[2]950					950	S	1.945	S−
	19	[2]953			953	U			929	930		929	S	1.938	S−
	20	[2]962			962	U				933		933	S−	1.943	S−
	21	906	931	959	927	S−	942					942	S−	1.934	S−
	22	928	939		933	S	[2]955					955	S−	1.944	S−
	23	918	927		922	S								1.922	S−
	24	930		940	933	S−			950	930		943	S−	1.938	S
	25	942	946	948	945	S	941	938				940	S	1.942	S
	26	943	950		946	S		949	935			941	S	1.944	S
	27	914	929	925	922	S			933	950		940	S−	1.931	S−
	28		957	967	960	S−		938	946	946		944	S	1.952	S
	29	927	946		937	S−	[2]952					952	S	1.944	S
	30	907	905		906	S								1.906	S
July	1	924	906	915	915	U		948	937	935		939	S−	1.939	S−
	2	936	912		919	U	955	941	943			946	S	1.946	S
	3	[2]942			942	S−		[2]947				947	S−	1.945	S
	4	[2]891			891	U								1.891	U
	5	943	943		943	S								1.943	S
	6	933	943		938	S								1.938	S
	7	914	926		920	S−								1.920	S−
	8	[2]937			937	U+								1.937	U+
	9	921			921	U	[2]959					959	S	1.959	S
	10	948			948	U	955	[2]968				964	S	1.964	S
	11							954	927	930		936	S−	1.936	S−
	12														
	13						[2]951					951	S	1.951	S
	14						[3]954					954	S	1.954	S
	15										017	017	U	2.017	U
	16														
	17	[2]945			945	U								1.945	U
	18	[2]961			961	U								1.961	U
	19	[2]928			928	U								1.928	U
	20	[2]940			940	U	946	957				952	S−	1.952	S−
	21		[2]936		936	U	[3]959					959	S	1.959	S
	22	[2]952			952	U	[3]951					951	S	1.951	S
	23	962			962	U								1.962	U
	24														
	25	[2]938			938	U	951	951				951	S	1.951	S
	26	[2]920			920	U+	[3]925					925	S	1.923	S
	27	929			929	U	[2]921					921	S−	1.925	S
	28						955					955	S−	1.955	S−
	29							[2]949				949	S	1.949	S
	30														

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922*—Continued.

		H. H solar constant.					Montezuma solar constant.							Weighted mean.	Grade.
		1.3	2.0	2.7	Mean.	Grade.	1.5	2.0	2.5	3.0	Long.	Mean.	Grade.		
1921.															
July	31							938				938	S−	1.938	S−
Aug.	1														
	2	[2]938			938	S	949	914	942		912	935	S	1.936	S
	3														
	4														
	5														
	6														
	7		[2]945		945	S−								1.945	S−
	8														
	9	[2]916			916	S−								1.916	S−
	10	[2]937			937	S−								1.937	S−
	11	951			951	S−								1.951	S−
	12	956	937		946	S−								1.946	S−
	13														
	14	944	948		946	S								1.946	S
	15	947	945	930	943	S−								1.943	S−
	16	947			947	S−								1.947	S−
	17	990	841	867											
	18														
	19														
	20														
	21														
	22														
	23	948			948	U									
	24	[2]948			948	U									
	25	941			941	U									
	26														
	27														
	28	919			919	S−								1.919	S−
	29														
	30	911	926	890	913	S−								1.913	S−
	31	935	941	931	938	U									
Sept.	1	940	935	917	933	S								1.933	S
	2			[2]929	929	S−								1.929	S−
	3	941	949	931	942	S								1.942	S
	4	936	947		941	S								1.941	S
	5	934	946	942	940	S								1.940	S
	6	944	936	920	936	S								1.936	S
	7	934	952	944	943	S								1.943	S
	8	936	934		935	S−								1.935	S−
	9	944	959		951	S								1.951	S
	10	952	955	945	952	S								1.952	S
	11			[2]953	953	S−								1.953	S−
	12		[2]947		947	S−								1.947	S−
	13	945	954		949	S−								1.949	S−
	14	945	958	955	952	S								1.952	S
	15	[2]944			944	S−								1.944	S−
	16		[2]941		941	S−								1.941	S−
	17	948	947	942	946	S								1.946	S
	18	951	948		950	S								1.950	S
	19	939	945	948	943	S								1.943	S
	20	938	949	949	945	S								1.945	S
	21	943	949		946	S								1.946	S
	22														
	23	946			946	U								1.946	U
	24	934	942	959	942	S−					937	937	S−	1.939	S
	25	924	932		928	S−	968				963	965	S	1.946	S−
	26	932	938	938	936	S								1.936	S
	27	941	933	947	939	S			946	929	970	954	S	1.947	S
	28						945			929	972	953	S	1.953	S
	29														
	30						939	951	953	976	955	955	S	1.955	S
Oct.	1														
	2														
	3	945	970	977	961	S	972		934	924	933	930	S	1.945	S−
	4	934			934	U+	963	957	950		966	959	S	1.946	S
	5	[2]932			932	S	945	935	931		939	938	S	1.935	S
	6						949				983	960	S	1.960	S
	7	947	948	954	949	S	959	945	925		967	952	S	1.951	S
	8	923	949		936	S−	911		949		937	932	S	1.934	S
	9	934	942	936	937	S		927			931	929	S	1.933	S
	10	940	939	933	938	S					023	023	U	1.938	S−
	11	922	945		933	U								1.933	U
	12		932	928	933	U								1.933	U
	13						931	957				944	S−	1.944	S−
	14	935	914		925	U									
	15	920	947	933	933	S								1.933	S
	16		[2]945		945	S−			962			962	S−	1.953	S−
	17	937			937	U								1.937	U
	18	933	940		937	S−					001	001	U	1.937	S−
	19	943	954	942	947	S								1.947	S
	20		959		959	S−								1.959	S−
	21	930	938	933	934	S								1.934	S
	22	927			927	U					938	938	S	1.938	S
	23							958	953		975	962	S	1.962	S
	24														
	25		942		942	U								1.942	U
	26	952	957	940	952	S								1.952	S
	27	933	947	970	946	S−								1.946	S−
	28		962		962	S−								1.962	S−
	29	941	965	961	955	S								1.955	S
	30		[2]962		962	S								1.962	S−
	31		954	960	957	S								1.957	S
Nov.	1		[2]949		949	S−								1.949	S−
	2	940	960	946	955	S								1.955	S
	3		949	931	943	S−								1.943	S−
	4		[2]946		946	S−	[2]952					952	S	1.949	S
	5														
	6														
	7		957	977	967	S−								1.967	S−
	8		[2]963		963	S−								1.963	S−

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922*—Continued.

	H. H. solar constant.					Montezuma solar constant.							Weighted mean.	Grade.
	1.3	2.0	2.7	Mean.	Grade.	1.5	2.0	2.5	3.0	Long.	Mean.	Grade.		
1921. Nov. 9														
10		962	951	956	S−								1.956	S−
11			961	961	U+								1.961	U+
12														
13		972	967	969	S								1.969	S
14		969	972	970	S								1.970	S
15		944	951	947	S				907		907	U	1.947	S−
16						[2]944					944	S	1.944	S
17						962	969	974		950	962	S	1.962	S
18		[2]950		950	S	945	945	934		936	940	S	1.945	S
19		[2]957		957	S−	938	952	945		891	937	S	1.947	S
20		959	942	946	S	955	963	955			958	S	1.952	S
21		983	961	972	S−	950	957	963		950	955	S	1.963	S
22		981	963	975	S−								1.975	S−
23		[2]956		956	U	946	934			900	932	S	1.932	S
24							973	956			962	S−	1.962	S−
25		[2]964		964	U	944	945	921		954	944	S	1.944	S
26		972	959	968	U	950	948	951		943	948	S	1.948	S
27		962	968	964	S−	957	961	949			956	S	1.960	S
28		[2]954		954	S−	[2]963					963	S	1.959	S
29							[2]946				946	S	1.946	S
30														
Dec. 1						[2]962					962	S	1.962	S
2		957	948	954	S	945	941	940		952	944	S+	1.949	S
3		917	936	923	S−	953	949	935			946	S	1.935	S−
4		[2]935		935	S−	952	957	950			953	S	1.944	S
5						964	951	946			953	S	1.953	S
6						952	946	929			945	S	1.945	S
7		940	957	946	S	[2]968					968	S	1.957	S
8		949	965	954	S	[2]970					970	S−	1.962	S−
9		961	964	962	S	961	958	945		975	960	S	1.961	S
10						956	936	961			947	U+	1.947	U+
11		[2]940		940	S−	953	949	940			947	S	1.944	S
12		964	956	961	S								1.961	S−
13														
14						938	928	913			926	S	1.926	S
15		956	967	960	S−								1.960	S−
16														
17														
18														
19														
20														
21														
22														
23		956		956	S−								1.956	S−
24														
25														
26														
27														
28														
29														
30			940	940	U								1.940	U
1922. Jan. 1														
2														
3														
4		[2]931		931	S−								1.931	S−
5			941	941	S−								1.941	S−
6														
7														
8						923					923	S−	1.923	S−
9		928		928	S−								1.928	S−
10		945		945	U								1.945	U
11						947	903				932	U	1.932	U
12		[2]937		937	S−	937	904				922	S−	1.929	S
13		958	947	954	S	937	947				942	S−	1.948	S
14		952		952	U	[2]941					941	S−	1.941	S−
15		941	941	941	S	[2]954	950				952	S	1.946	S
16		947	947	947	S	971	969				970	S	1.959	S−
17		[2]953		953	U	947	951	951			949	S	1.949	S
18		[2]952		952	U								1.952	U
19							958				958	S−	1.958	S−
20		940	937	938	S					936	936	S	1.937	S
21		939	941	940	S					959	959	S	1.950	S
22		954	939	946	S					941	941	S	1.943	S
23														
24		945	914	935	U+					957	957	S	1.946	S−
25		940	930	937	S					927	927	S	1.932	S
26		947	939	943	S−					936	936	S	1.939	S
27										944	944	S	1.944	S−
28		910	922	916	U					951	951	S	1.951	S
29														
30										987	987	S	1.987	S−
31										959	959	S	1.959	S−
Feb. 1														
2		934	933	934	S								1.934	S
3		939		939	U								1.939	U
4		946		946	U								1.946	U
5														
6		957	952	955	S−								1.955	S−
7														
8														
9														
10										910	910	S−	1.910	S−
11														
12		961	948	954	S					977	977	U	1.951	S−
13		956	952	955	S					938	938	S	1.946	S
14		932		932	U								1.932	U
15										967	967	S−	1.967	S−
16		953	963	958	S−								1.958	S−
17		950	945	947	S−								1.947	S−
1922. Feb. 18		947	957	952	S−					996	996	U	1.952	S−
19	[2]949			949	U					932	932	S−	1.932	S−
20		[2]948		948	S−								1.948	S−
21														
22		941		941	U					958	958	S	1.958	S−
23										930	930	S	1.930	S−
24										969	969	S	1.969	S−
25	945			945	U					936	936	S	1.936	S−
26														
27														
28		913	922	917	U					940	940	S	1.940	S−
Mar. 1		912	886	912	U								1.912	U
2		948	935	944	S					874	874	U	1.944	S−
3	[2]936			936	U					932	932	S	1.932	S
4		[2]939		939	S					059	059	U	1.939	S−
5		[2]909		909	U								1.909	U
6		[2]933		933	S−					880	880	U	1.933	S−
7										965	965	S	1.965	S−
8		932	927	930	S−					892	892	U	1.930	S−
9		888	823	888	U									
10		917	922	920	S−					003	003	U	1.920	S−
11										963	963	S	1.963	S−
12										947	947	S	1.947	S−
13		946	932	941	S−					908	908	S	1.924	S−
14	940			940	U								1.940	U
15														
16														
17						933					933	S−	1.933	S−
18		941	940	940	S								1.940	S
19		912	917	915	S								1.915	S−
20														
21														
22						[2]936					936	S	1.936	S−
23	[2]878			878	U	944	928			957	943	S−	1.943	S−
24	934	933		934	S−	[2]937	913				932	S−	1.933	S
25						[2]925	880				925	S−	1.925	S−
26	908	901		905	S								1.905	S
27	[2]913			913	S			919			919	S−	1.916	S
28														
29	[2]941			941	S−								1.941	S−
30														
31														
Apr. 1	[2]939			939	S−								1.939	S−
2	943	935		939	S−								1.939	S−
3	932	917	922	924	S								1.924	S
4														
5						936	[2]922				929	S	1.929	S
6						927	907	891			917	S	1.917	S
7	931	933		932	S	921	909	893		958	927	S−	1.930	S
8	923	895	857	923	U	[2]937					937	S	1.937	S−
9								935	877		935	S−	1.935	S−
10	[2]921			921	S−								1.921	S−
11	921	914		918	S−	[2]940	927				939	S	1.928	S
12		906	923	915	S−		[2]894	831			886	U	1.915	S−
13	[2]934			934	U				995		995	U		
14	928	921		925	S								1.925	S
15	921	910	899	912	S−								1.912	S−
16	[2]937			937	S−								1.937	S−
17	922	926		924	S								1.924	S
18						[2]935					935	S	1.935	S
19	918	902		910	S−	[2]935					935	S	1.923	S−
20	919	928		923	S								1.923	S
21														
22			[2]885	885	U	[2]918					918	S	1.918	S
23	[2]933			933	S−								1.933	S−
24	916	893	861	895	U								1.895	U
25														
26	918	910		914	S−								1.914	S−
27	887	861	825	864	U								1.864	U
28	[2]907			907	S−								1.907	S−
29						941					941	S	1.941	S−
30	950	937		943	S−		[2]912				912	S	1.927	S−
May 1	939	929		934	S−								1.934	S−
2	927	910	891	915	U								1.915	U
3	919	900		910	U								1.910	U
4	921	916		919	S−								1.919	S−
5	921		906	914	U								1.914	U
6														
7	932	959		945	U								1.945	U
8									910		910	S−	1.910	S−
9						908	867	857			886	S−	1.886	S−
10		920	923	922	U	939	934	912		958	936	S−	1.936	S−
11	939	930	918	931	S				[2]922		922	S	1.927	S
12	939	927		931	S	[2]932					932	S	1.932	S
13	929	940		934	S								1.934	S
14	922	923		923	S								1.923	S
15	[2]942			942	S−								1.942	S−
16	944	946	945	945	S								1.945	S
17		922	917	920	S−								1.910	S−
18		945	926	935	S−								1.935	S−
19	937	933		935	S	912	893	936			918	U	1.935	S−
20		942	938	940	S								1.940	S
21	934	942		938	S								1.938	S
22	935	931	919	930	S								1.930	S
23														
24														
25	942	919	913	927	U								1.927	U
26	938	936		937	S−								1.937	S−
27	942	932		937	S								1.937	S
28	900	894		897	S								1.897	S
29	917	900		908	U+								1.908	U+

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922*—Continued.

	H. H. solar constant.					Montezuma solar constant.							Weighted mean.	Grade.
	1.3	2.0	2.7	Mean.	Grade.	1.5	2.0	2.5	3.0	Long.	Mean.	Grade.		
1922 May 30	^{2}932			932	U+								1.932	U+
31	915	913		914	U+								1.914	U+
June 1	931	914		922	S		903	906			905	S	1.913	S
2	^{2}931			931	S−		890	911			904	S	1.917	S−
3	942	944	941	943	S	915	924				919	S	1.931	S
4	938	928		933	S								1.933	S
5	927	931		929	S								1.929	S
6	934	944	944	940	S								1.940	S
7	941	940		940	S−	903	888	876			889	U	1.940	S−
8	^{2}942			942	U								1.942	U
9	^{2}944	953		948	S−								1.948	S−
10	937	951	949	945	S								1.945	S
11		941		941	S−								1.941	S−
12														
13	^{2}925			925	U								1.925	U
14		925	913	921	S			905			905	S−	1.913	S
15	920	926	913	921	S		898	923		934	922	S	1.922	S
16	923	936		930	S	^{2}931					931	S−	1.930	S
17	916	909	914	913	S								1.913	S
18	921	899		910	S−								1.910	S−
19	904	886		895	S		890				890	S−	1.892	S
20	882	881		882	S								1.882	S
21	^{2}880			880	S−								1.880	S−
22														
23														
24	^{2}897			897	U+								1.897	U+
25							934	900			922	S−	1.923	S−
26	892	898		895	S−								1.895	S−
27	908	962	009	908	U									
28	880	877	880	880	S−								1.880	S−
29	872	908		890	S−		901	890			897	S−	1.893	S
30	960	958		959	S		^{2}943	918			938	S−	1.948	S−
July 1	^{2}920			920	U+	920	898				913	S−	1.913	S−
2	^{2}864			864	U+		^{2}898	870			893	S−	1.893	S−
3	^{3}908			908	S−								1.908	S−
4	^{2}896			896	S−								1.896	S−
5	882	871	920	883	S−								1.883	S−
6														
7														
8	884	870	901	882	S								1.882	S
9	900	896		898	S−								1.898	S−
10	905	918		911	S−								1.911	S−
11	^{2}927			927	S−								1.927	S−
12		914	945	929	S	925	917	896			916	S−	1.921	S
13		943	930	936	S			^{2}888			888	S	1.912	U
14	905	916	913	912	S				^{3}913		913	S−	1.912	S
15	896	910		903	S−	^{2}929					929	S	1.920	S−
16	^{2}907			907	S−								1.907	S−
17	^{2}906			906	U								1.906	U
18	^{3}916			916	S−								1.916	S−
19														
20	892			892	U								1.892	U
21	950	943		947	U								1.947	U
22	926	933	929	929	S−								1.929	S−
23	^{2}925			925	S−								1.925	S−
24	^{2}926			926	S−								1.926	S−
25														
26														
27	^{2}918			918	U								1.918	U
28	928			928	U		917	887			907	S−	1.907	S−
29						^{3}927					927	S−	1.927	S−
30	^{2}903			903	U								1.903	U
Aug. 1						920	883				908	S−	1.908	S−
2														
3	911	901	933	912	S								1.912	S
4	913	917		915	S								1.915	S
5	^{3}889			889	U		915				915	S−	1.915	S−
6														
7														
8						931					931	S−	1.931	S−
9														
10														
11								^{2}903			903	S−	1.903	S−
12	^{2}921			921	S−	921	934	926		976	934	S	1.927	S
13														
14	943	946		945	S								1.945	S
15	^{2}920			920	U+								1.920	U+
16	905			905	U								1.905	U
17														
18														
19							^{2}907				907	S−	1.907	S−
20														
21		^{2}943		943	U									
22														
23														
24														
25	895	910	895	901	S−								1.901	S−
26		916	942	925	S−				906		906	S−	1.915	S−
27		912	937	920	S−		941	909			920	S−	1.920	S
28	908	935	971	931	U	937					937	S−	1.934	U
29		943	921	936	U								1.936	U
30	923	929		926	U	^{3}917					917	S−	1.917	S−
31	^{2}912			912	U+								1.912	U+
Sept. 1	935	939		937	U+								1.937	U+
2														
3	892	888		890	S−								1.890	S−
4	927	955	929	939	S−								1.939	S−
5	^{2}928			928	S−								1.929	S−
6														
7														
8														

[a] Small figures like exponents indicate number of observations used in obtaining the mean.

TABLE 8.—*Harqua Hala and Montezuma values, October, 1920, to September 20, 1922*—Continued.

	H. H. solar constant.					Montezuma solar constant.							Weighted mean.	Grade.
	1.3	2.0	2.7	Mean.	Grade.	1.5	2.0	2.5	3.0	Long.	Mean.	Grade.		
1922 Sept. 9	919	946		928	S−								1.928	S−
10	919	900	891	905	S−								1.905	S−
11	^{2}916			916	S−								1.916	S−
12	^{2}900	919	946	916	S−								1.916	S−
13														
14	894	884	872	885	S−								1.885	S−
15	881	876		879	S−	936					936	U	1.879	S−
16	^{3}871			871	S−	936	920	925			927	S−	1.899	S−
17		857	856	857	U?								1.857	U?
18	^{3}866			866	S−								1.866	S−
19	860	830	804	860	U?								1.860	U?
20	861	873		867	S−		934				934	S−	1.900	S−

[a] Small figures like exponents indicate number of observations used in obtaining the mean.

DENSE FOG IN THE TRI-CITIES ON NOVEMBER 3, 1922.

E. E. UNGER, Observer.

[Weather Bureau Office, Davenport, Iowa, February 28, 1923.]

London had nothing on the Tri-Cities in the matter of fog this morning, up to nearly 9. One of the densest fog blankets which ever settled over this section enveloped the community, making it impossible for pedestrians and autoists to see even as far as across the street.—From *The Moline Dispatch*, November 3.

What may be characterized as the heaviest fog, or at least one of the heaviest, that ever occurred in the Tri-Cities (Davenport, Iowa, and Rock Island and Moline, Ill.), began as light fog at about 1 a. m. on Friday, November 3, 1922, changing to dense fog at about 2 a. m. and continuing dense to about 9 a. m. after which light fog prevailed to about 1 p. m.

Between the hours of 6 and 8 a. m., when the fog was apparently the heaviest, the curbings across the streets, shrubbery in yards, openings in buildings, and pedestrians were entirely invisible to one at distances of from 40 to 50 feet, while large objects, such as automobiles, buildings and the like could not be seen even faintly 50 to 75 feet away. Lights on automobiles, locomotives, street cars, and street lights could not be distinguished at distances of 125 to 300 feet away, depending on their intensity.

Different persons were called up on the telephone from the Weather Bureau office during the forenoon of November 3, in most cases before the fog had dissipated, and questioned relative to the density of the fog and the visibility. It is thought that most of the distances given are fairly accurate, due to the fact that generally they were supplemented in terms of width of street, length of block, width of city lot, etc., thus "Can not see house across street," "Could not see opposite curb from walk," "A person crossing the street becomes invisible when stepping up on opposite curb," "Could not see an automobile down town at the distance of the width of the street," "Could first see lights of approaching automobile about a half block away," and the like. The width of streets in the residential sections of the Tri-Cities average about 30 feet from curb to curb, while in the business sections they probably average about 60 feet.

The fog would compare favorably in intensity with the heavy fogs common at stations on the Atlantic and Pacific coasts. However, the formation of such a heavy fog in the Middle West is quite unusual. Light fogs in this section are not infrequent, especially during the autumn and winter months, but dense fogs where one can not see the faint outline of a building by day or a street light by night at a distance of 500 to 700 feet have never occurred